mi Sanders

A GEC-MARCONI ELECTRONICS COMPANY

6420
6421
6422

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5 SEP 1975

tft

POWER HEADS

INSTRUCTION MANUAL

MARCONI INSTRUMENTS LTD
SANDERS DIVISION STEVENAGE

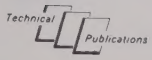
MP MASTER
MA23610

INSTRUCTION MANUAL

for

TYPES 6420
6421
6422

tft POWER HEADS



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MARCONI INSTRUMENTS LIMITED
SANDERS DIVISION
STEVENAGE HERTFORDSHIRE ENGLAND

A GEC-MARCONI ELECTRONICS COMPANY

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Chapter 1

General information

1.1 GENERAL DESCRIPTION

Type 6420, 6421 and 6422 are three coaxial tft(R)* Power Heads designed for the measurement of radio frequency signals over an extremely wide range of power and frequency.** These units are intended for use with the MI/Sanders type 6460 and 6550A Thermoelectric Power Meters and will measure amplitude and frequency modulated as well as CW signals. The power range of the Coaxial tft Power Heads when used with the Type 6460 extends from 0.03 microwatt on the most sensitive range to 100 milliwatts full scale on the highest power range and from 10 microwatts when used with a type 6550A. Still higher powers can be measured using the MI/Sanders Type 6423 tft Power Head (up to 3 watts) or suitably calibrated couplers or attenuators. Frequency coverage extends from 10MHz to 12.4GHz for each of the models.

* thin-film thermoelectric

** U.S.Patent 3,384,819

Chapter 2

Operation

2.1 OPERATING INSTRUCTIONS

To place the tft Power Head into use, first connect it to a tft powermeter and zero the instrument to balance out residual thermal emf's. (The detailed operating procedures for the Type 6460 and 6550A are given in the Operating and Service Manuals supplied with those instruments.) If automatic correction for effective efficiency is desired, interpolate the efficiency from the graph supplied with the mount and set the efficiency control at the rear of the mount to that number. It is reasonable to assume a smooth curve between the measured points. Each unit is measured on a swept basis over most of the band to ensure that there are no "holes" over that range. If this is not convenient or desirable, set the control to 100% and correct the readings obtained by calculation. This procedure is in fact the more accurate of the two since manufacturing tolerances on parts and components result in a small error in the correction circuitry. For effective efficiencies of 90% and with tft elements at the limits of acceptable sensitivity, this error can be as high as about 1%. Typically, however, the error will be less than 0.5%. The tft Power Head should then be connected to the r-f system under test and the r-f power will be indicated on the tft Powermeter.

Although the tft Power Heads are rugged, dependable units that will give reliable trouble-free service when operated within their ratings, they are subject to burn-out when overloaded. Table 1 lists the power ratings for the three models.

Chapter 2

Operation

Table 1 – Power Ratings for tft Power Heads

Model	Average Power, Continuous Duty	Max. Peak Power*	Max. D-C Voltage
6420	10mW	3W	10V
6421	100mW	30W	30V
6422	1mW	0.3W	3V

*Tentative Ratings for PRF's greater than 50Hz.

At lower frequencies this should be reduced.

While the tft Power Heads will take overloads of up to 300% for short periods of time, extended periods of operation at this level or exceeding these ratings may result in permanent change in the tft element characteristics or even burnout. Maximum care should be exercised to avoid its occurence.

2.2 CAUTION

Although a blocking capacitor is located in series with the tft Power Head coaxial centre conductor, the presence of d-c voltage on the coaxial line to which the Power Head is connected may cause burn-out due to the flow of a

large transient current. To avoid this it is recommended that the maximum d-c voltage applied to the mount be limited in accordance with table 1 above. If it is essential that higher voltages be employed than those listed, the following procedures should be employed:

2.2.1. Turn down the d-c voltage to zero volts.

2.2.2. Connect the Power Head to the r-f power source being measured.

2.2.3. Turn up the d-c voltage slowly to the desired level.

Under these circumstances, the maximum applied voltage may be as high as 100 volts for all models.

Chapter 3

Technical description

3.1 DESIGN DETAILS

The tft Power Heads incorporate a thin-film metallic load which, acting as a well-matched termination, absorbs the incident r-f power. The load consists of bismuth and antimony sections which are vacuum deposited on a thin dielectric substrate in a geometric configuration that produces a number of thermoelectric junctions. Some of the junctions are thermally "sinked" to the transmission line while the remaining junctions are located in the air space between the lines. The absorbed r-f power raises the temperature of these latter junctions relative to the "sinked" junctions and thus a thermoelectric emf is generated proportional to the temperature rise. By keeping the temperature differential between the junctions small, the unit acts as a true square-law (rms) device producing a d-c output voltage directly proportional to the absorbed power.

The tft Power Heads are designed to be used with the MI/Sanders 6460, and 6550A which are equipped with the following special features:

3.1.1. Direct reading in power. No conversion required.

3.1.2. Automatic adjustment for each tft Power Head sensitivity factor.

3.1.3. Interlock circuitry to ensure proper scale selection.

3.1.4. Compensation circuits to correct for sensitivity factor temperature coefficient

3.1.5. Shielded low noise connector.

Chapter 3

Technical description

They may also be used with any other d-c voltmeter that offers adequate sensitivity and accuracy. It is recommended that the factory be consulted on special instrumentation problems.

3.2 SOURCES OF ERROR

There are two primary sources of error that are common to most power measuring devices. These are best described by the terms mismatch and efficiency errors.

3.2.1. Mismatch errors

The ideal power sensing device would be completely reflectionless, absorbing all the power that is incident upon it. Although all models of coaxial tft Power Heads are very well matched over an extremely broad band of frequencies, there may still be a significant amount of power reflected at some frequencies, e.g. when the VSWR reaches the maximum rated value of 1.5, the power reflected to a matched source will be 4%.

In order to account exactly for the mismatch error, one must know the complex impedances of both generator and load. In most circumstances, it is not convenient to measure these quantities. Nevertheless, with a knowledge of the magnitude of these two quantities, it is possible to establish an upper bound on this error with the use of the following equation:

$$\text{Mismatch error} = \frac{(1 - |\Gamma_g|^2)(1 - |\Gamma_L|^2)}{(1 \pm |\Gamma_g \Gamma_L|)^2}$$

where Γ_g = the generator reflection coefficient.

Γ_L = the load reflection coefficient, and

$$\Gamma = \frac{\text{VSWR}-1}{\text{VSWR}+1}$$

Figure 1 is a graph of the limits of mismatch error as a function of generator and load VSWR

3.2.2. Efficiency errors

Although the usual definitions of mount efficiency as applied to barretters and thermistors do not apply to tft Power Heads, since these devices do not depend directly upon substitution power to effect a measurement, an equivalent error exists which is a result of the frequency dependent response of the unit. As described below, calibration of the tft Power Heads can be performed at audio frequencies, and, in fact, this is one of the factory procedures employed.

Although ideally the Joule heating effect of the audio power used in calibration and the r-f power to be measured should be the same, thereby giving rise to the same thermoelectric emf, in practice, some of the r-f power is absorbed by the mount is lost in the metallic conductors and dielectric supports of the mount as well as in the r-f bypass capacitors and contacts of the tft element.

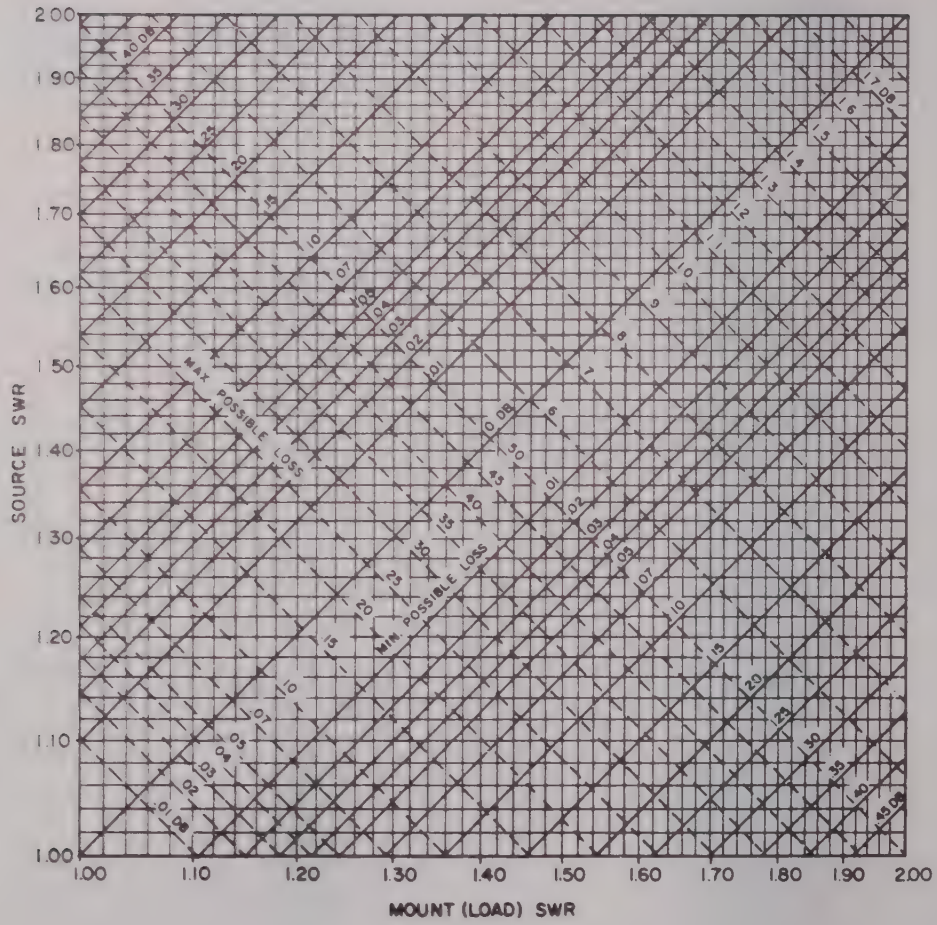


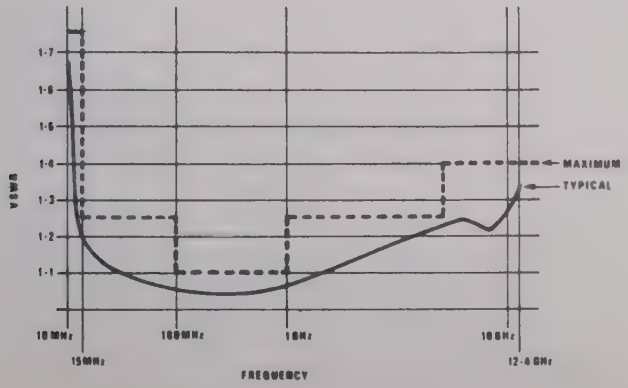
Figure 1. Mismatch Loss Limits

Chapter 3

Technical description

It is convenient to define the term effective efficiency for a tft Power Head as the ratio of the audio power to the total absorbed r-f power required to produce equal d-c output voltages from the power head. Each coaxial tft Power Head is tested at the factory for effective efficiency at the fixed frequencies of 1.0, 3.0, 6.0, 8.0, 10.0 and 12.4GHz and over most of the band on a swept frequency basis. The effective efficiency data obtained at the fixed frequencies is stamped on the metal graph mounted on the power head cover. All models of coaxial tft Power Heads have typical efficiencies of 99% at 1GHz and are more than 90% efficient up to 12.4GHz.

A systematic correction for mismatch error cannot be applied since, as stated above, it depends upon both mount and generator VSWR. However, efficiency errors can be corrected unambiguously if the operating frequency is known since this depends solely upon the mount characteristics. For this purpose, a control is provided at the rear of each coaxial tft Power Head calibrated directly in terms of effective efficiency. When this control is set to the measured or interpolated value of effective efficiency for the frequency in use, the Type 6460 and 6550A Thermoelectric Power Meters will automatically correct for and eliminate this error. Correction range extends from 90 to 100% on all models.



Chapter 4

Maintenance

4.1 GENERAL MAINTENANCE

Except for replacement of tft elements, maintenance should not be required for tft Power Heads.

4.2 REPLACEMENT OF ELEMENTS

To check the tft element, verify that the resistance between pins 1 & 3 on connector P1 is approximately 200 ohms. DO NOT USE THE R ÷ 100 OHMMETER RANGE.

When spare tft elements are required for field replacement, they should be ordered in accordance with the following:

Type No. tft Power Head	Type No. tft element
6420	TL–0A
6421	TL–1A
6422	TL–2A (see note on page 21)

If factory replacement of tft elements is desired return the unit to the Service Dept, Marconi Instruments, Sanders Division, P.O. Box No. 10, Stevenage, Herts. England SG1 2AU, with a request for service.

Referring to the exploded view, figure 2, for parts identification, proceed as follows for field replacement of tft elements. It is recommended that MI/Sanders tool kit 3850–TK–1 be employed in the replacement procedure to prevent accidental damage to the tft elements.

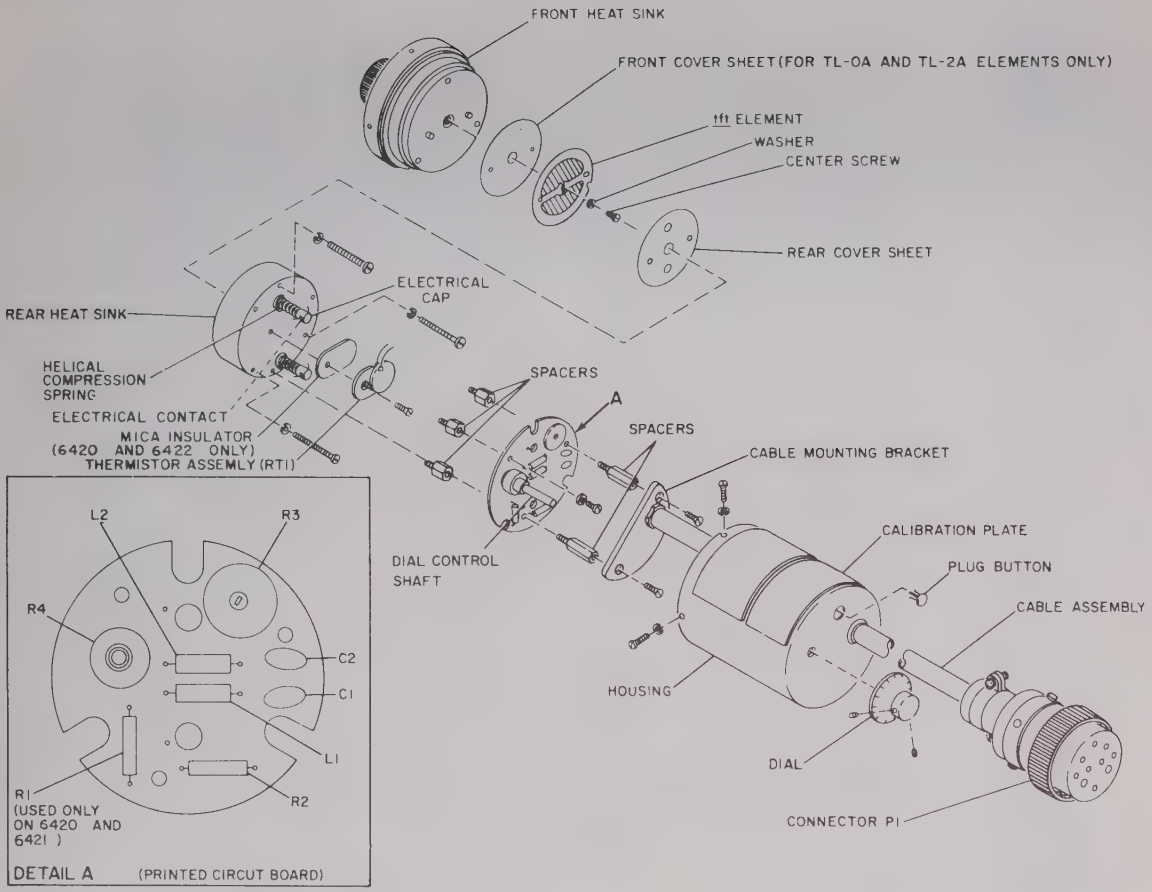


Figure 2. Exploded View, Type 6420, 6421, 6422

4.2.1. Remove the dial from the dial control shaft.

4.2.2. Remove the three screws and washers which secure the housing to the front heat sink assembly. Slip the housing off the power head assembly until it is free on the cable assembly.

4.2.3. Remove the three screws and washers which secure the rear heat sink assembly to the front heat sink assembly, and remove the rear heat sink assembly.

4.2.4. Using the tool kit screwdriver, remove the centre screw and washer securing the tft element to the front heat sink assembly.

4.2.5. Remove the tft element and cover sheet(s).

4.2.6. Clean the two mounting surfaces of the power head with a cotton swab, using acetone or another residue-free cleaning agent. After cleaning, inspect the two surfaces to determine that all foreign particles have been removed.

4.2.7. Clean the replacement cover sheets with acetone before installation.

4.2.8. Inspect the tft element. If any foreign particles are detected, remove them with a dry swab. Do not clean with acetone. The tft element should be handled with tweezers such as are included in MI/S Tool Kit 3850–TK–1. Make sure that the tweezers do not touch the film area of the element.

4.2.9. Using the tool kit tweezers, install the replacement tft element and new cover sheet(s) over the pins of the front heat sink assembly. Do not re-use old cover sheet(s).

4.2.10. Although these parts will fit over the pins in several orientations, there is only one that will correctly align the centre of the element with the centre conductor of the front heat sink assembly.

4.2.11 Slip the tool kit assembly jig over the front heat sink assembly pins and insert the new washer furnished with the replacement tft element in the centre hole of the assembly jig. Ensure that the countersink in the washer faces away from the tft element.

4.2.12. Using the new centre screw furnished with the replacement tft element, apply sufficient torque to firmly seat the tft element. Remove the assembly jig.

NOTE

If a torque screwdriver is used for step 4.2.12 set it to 4±¼ ounce-inches.

4.2.13. Reassemble the rear heat sink assembly to the front heat sink assembly, making sure that sufficient torque is transmitted to firmly secure the two assemblies.

4.2.14. Reattach the housing to the front heat sink assembly and secure.

4.2.15. After the power head has been assembled, measure the resistance from Pins 1 and 3 to ground, using the R x 100 range on the ohmmeter. It should read open circuit. If not, there is a short in the mount, which may be due to a foreign particle in the assembly. If this occurs, the mount should be disassembled, cleaned as described above, and reassembled.

4.2.16. Rotate the dial control shaft fully clockwise, set the dial to read 100% and secure.

4.2.17. Perform the procedures described in 4.4.3.

4.3 REPLACEMENT OF THERMISTOR ASSEMBLY

To replace the thermistor assembly (RT1), perform steps 1 through 6 below. To replace any other electrical part, omit step 5.

4.3.1. Perform steps 4.2.1. and 4.2.2.

4.3.2. Remove the two screws which secure the cable mounting bracket to the spacers. Push the cable mounting bracket aside, and remove the two spacers.

4.3.3. Push the electrical caps back on the electrical contacts until the wires they secure come free. Remove the electrical caps and the helical compression springs.

4.3.4. Unsolder the thermistor assembly leads from the printed circuit board. Remove the screw which secures the printed circuit board and remove the board.

4.3.5. Remove the nylon screw which secures the thermistor assembly and the mica insulator.

4.3.6. Make the necessary replacements and reassemble the unit by performing the above steps in the reverse order.

Chapter 4

Maintenance

4.4 CALIBRATION

To recalibration the tft Power Head as part of a periodic calibration programme, it is acceptable to use either of the two procedures which follow.

If the r-f procedure is employed, a frequency of 1GHz or less is best so that mount efficieny errors can be ignored.

4.4.1 RF Calibration

With an r-f standard, a known level of power from a well-matched source (VSWR less than 1.02) should be established. A level close to the maximum rating of the tft Power Head is best to minimize drift and noise. The VSWR of the tft Power Head should be measured at the calibration frequency and the return loss computed. With the tft Power Head connected to the Model 6460 and the efficiency control set to 100, apply the r-f signal and adjust the calibration potentiometers R3 (see figure 4) to produce the desired reading including correction for the return loss. The calibration potentiometer is available at the rear of the Power Head housing by removing the metal plug under the notation CAL.

4.4.2. Audio Calibration

a. Connect the tft Power Head as shown in figure 3. Be sure to observe proper ground connections to avoid spurious ground loops. To check for this, prior to connecting the tft Power Head

observe the d-c voltmeter as the a-c generator output is varied. There should be no reading under these conditions. Disconnect the d-c voltmeter and observe that there is no change in the a-c voltmeter reading.

(b) Adjust the output of the 1KHz generator to the voltage indicated (approximately 10% below the maximum rated power of the head). Measure the rms audio input voltages (E and E_L) and the d-c output voltage E_{dc} and compute the sensitivity (S) as follows:

(FOR TYPE 6420 and 6422 ONLY)

$$S = \frac{E_{DC}}{\frac{(E - E_L)}{200}\left[E_L - \frac{1.5\,(E - E_L)}{200}\right]} \qquad \text{EQUATION (1)}$$

Compute the required value for the calibration resistance from the formula.

$$R = 971\,(AS - 0.103)$$

where A = 0.478 for the 6420 and

= 0.0478 for the 6422

Connect a precision resistance bridge between pins 8 and 9 of P1 and adjust R3 to produce the desired resistance.

(FOR TYPE 6421 ONLY)

Turn off the audio generator and promptly measure the resistance between pins 2 and 9 (R_s). Compute the sensitivity (S) as follows:

$$S = \frac{E_{DC}}{\frac{(E - E_L)}{200}\left[E_L - \frac{1.5\,(E - E_L)}{200}\right]} \qquad \text{EQUATION (2)}$$

Compute the required value for the calibration resistance from the formula:

$$R = \frac{100R_s}{100 + R_s}(46.38\,S - 1)$$

where S is in volts per watt and R_s is in ohms.

Connect a precision resistance bridge between pins 8 and 9 of P1 and adjust R3 to produce the desired resistance.

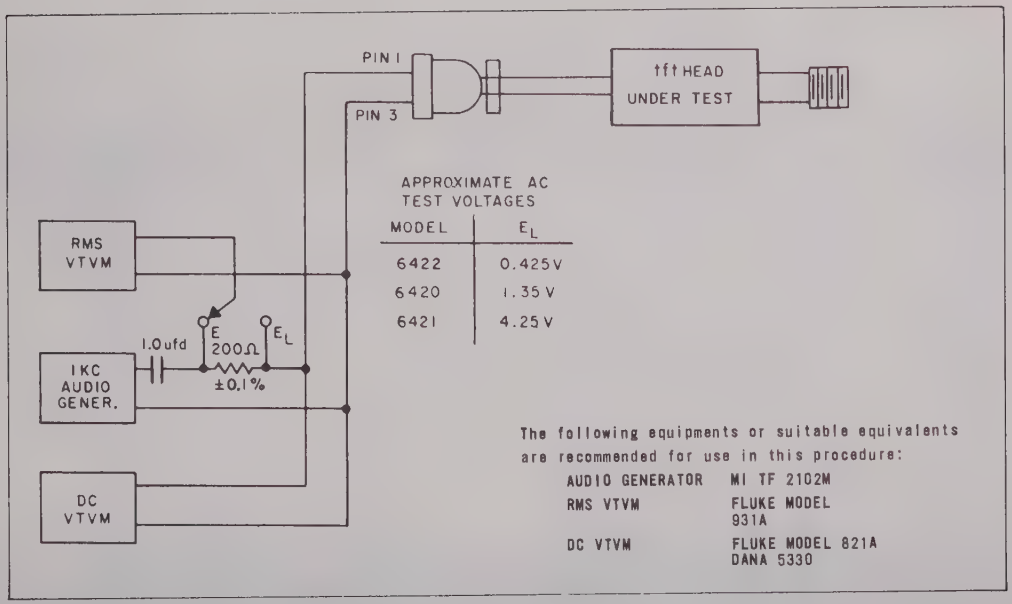


Figure 3. Test Set-Up for Audio Calibration

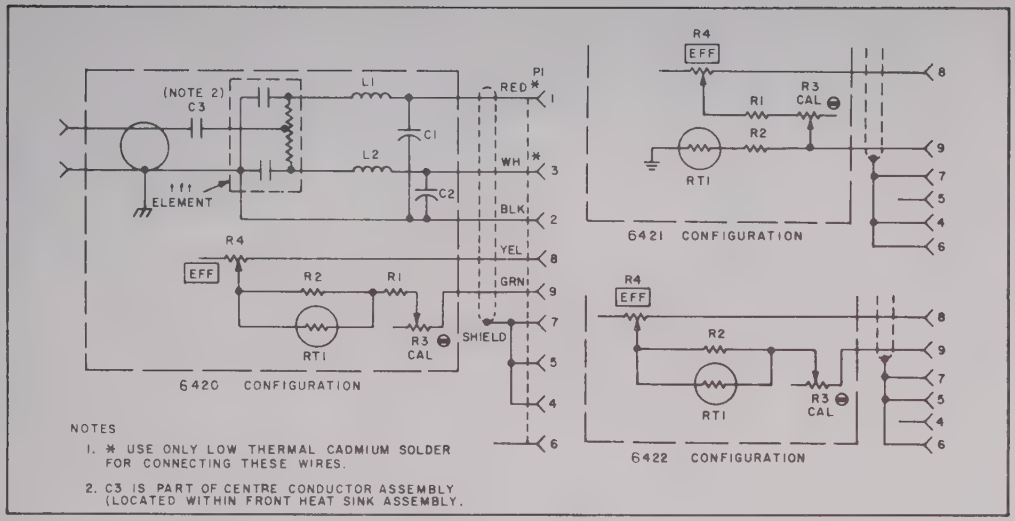


Figure 4. Schematic Diagram Models 6420, 6421, 6422.

4.4.3 Efficiency Determination

For recalibration when replacing tft elements, the mount should first be tested in accordance with the audio calibration procedure described above. RF effective efficiency can then be determined by measurement against r-f standards and the new efficiency factor marked on a new calibration plate and attached to the mount.

4.4.4 Calibration with Extension Cables

When using tft POWER HEADS in conjunction with extension cable assemblies, such as MI/Sanders type W967, W970 and W972, it is necessary to compensate for the resistance of the extension cable assemblies. Towards this end, it is acceptable to use any of the methods given below. (If the total length of the extension cable assemblies does not exceed ten feet, the resistance can be ignored.)

(a) Perform either the 4.4.1. or the 4.4.2. procedures described in this literature with the extension cable assemblies attached to the tft Power Head.

(b) Perform the described audio-calibration procedures and change the calibration formula in equation (1) and (2) as necessary from R = ( ) to R = ( ) –X where X = the resistance of the cable assemblies at 1 ohm per 20 feet.

(c) Perform the described RF calibration procedures and adjust the CAL potentiometer X ohms lower (See 2 above) than the value to which it would normally be adjusted. Make this adjustment at the conclusion of the described procedures.

4.5 ACCESORIES AVAILABLE

Tool Kit 3850 – TK-1 consisting of:

A. Assy. Jig

B. Screwdriver

C. Tweezers

C. Allen Key

NOTE

When ordering replacement tft elements for TYPE 6422 used with a cable length longer than the standard five-foot, it is necessary to specify tft element numbers in accordance with the following data:

Cumulative Cable Length (feet)	tft element Model No.
0–10	TL–2A/2600
10–49	TL–2A/2700
50–99	TL–2A/2750
100–149	TL–2A/2800
150–199	TL–2A/2850
200–249	TL–2A/2900
250–299	TL–2A/2950
300–349	TL–2A/3000
350–399	TL–2A/3050

These data apply equally to Models 6422 furnished with special cable lengths, and to standard Models 6422 with five-foot cables that are used in conjunction with extension cable assemblies, such as Models W967, W970 and W972.

Chapter 5

Replaceable parts

Ref. Sym.	Description	Part No.	Mfr.	Quantity Used per Article		
				6420	6421	6422
–	Screw, Miniature*	–	MI/S	1	1	1
–	Washer*	–	MI/S	1	1	1
–	Coves Sheet, Front*	–	MI/S	1	N/A	1
–	Cover Sheet, Rear*	–	MI/S	N/A	1	N/A
–	Cover Sheet, Rear*	–	MI/S	1	N/A	1
–	Cable, Sp. Elec.	3853/119	MI/S	5 ft.	5 ft.	5 ft.
–	Dial	3853/011	MI/S	1	1	N/A
–	Dial	3855/011	MI/S	N/A	N/A	1
–	Calibration Plate*	–	MI/S	1	1	1
C1, C2	Capacitor, Fxd. Ceramic; .01 μf ±20%, 100V	–	Comm.	2	2	2
C3	Capacitor, Fxd. Ceramic (Part of center conductor assembly)	3853/104	MI/S	1	1	1
L1, L2	Choke, RF, Fxd.	553-3635-17	Cambion	2	2	2
P1	Conn. Plug, Elec.	3853/120	MI/S	1	1	1
R1	Res. Fxd. Film 29.8Ω ±1%	M125	MANN	1	1	N/A
R1	Res. Fxd. Film 40.2Ω ±1%	M125	MANN	N/A	1	N/A
R2	Res. Fxd. Film 18.2Ω ±1%	M125	MANN	1	1	N/A
R2	Res. Fxd. Film 9.53Ω ±1%	M125	MANN	N/A	N/A	1
R3	Res. Var. WW 100Ω	84-3-R-101	Spectrol	1	1	1
R4	Res. Var. WW	3853/012	MI/S	1	1	N/A
R4	Res. Var. WW	3853/012	MI/S	N/A	N/A	1
RT1	Thermistor Assembly	3853/006	MI/S	1	1	1
–	tft Element	TL-0A	MI/S	1	N/A	N/A
–	tft Element	TL-1A	MI/S	N/A	1	N/A
–	tft Element	TL-2A (See note below)	MI/S	N/A	N/A	1

* Supplied with each replacement tft element

COMM – Common Part available from a number of manufacturers.

M.I. SANDERS tft POWER HEADS
LOW FREQUENCY VERSIONS

This Information, when used with this handbook provides all required data for the above versions.

The performance of the low frequency tft power head is the same as the corresponding standard version except that it has been modified to operate over the frequency range with V.S.W.R. Specification as shown below.

OPERATIONAL RANGE	500KHz - 1GHz	6420/11 10 mW	6421/11 100 mW	6422/11 1 mW			
	10KHz - 125MHz				6420/12 10 mW	6421/12 100 mW	6422/12 1 mW
VSWR LESS THAN 500KHz		1.5	1.5	1.5			
10KHz - 125MHz					1.5	1.5	1.5
2MHz - 1GHz		1.2	1.2	1.2			
MODIFICATIONS WHICH AFFECT THE CIRCUIT DIAGRAM AND REPLACEABLE PARTS LIST ARE AS FOLLOWS:- R1		52.3 ohm	52.3 ohm	0 ohm	52.3 ohm	52.3 ohm	0 ohm
C3, C4, C5 MISD. PT. No.		3867104	3867104	3867104	3868104	3868104	3868104

1. The effective efficiency potentiometer R4 has been deleted on all the heads mentioned in this information.
2. C4 and C5 are fitted in parallel with each of the two capacitors which are shown in the area identified as tft element in fig.4.
3. tft element cover sheet P/N 3155 has been replaced as follows:-

   3155-1 call for 6211-3
   3155-2 call for 6211-5

   It is important to specify the new part number when ordering spare tft elements.

TO ORDER REPLACEMENT ELEMENT KIT, STATE THE tft POWER HEAD TYPE NUMBER TO ENSURE CORRECT REPLACEMENT.

MARCONI INSTRUMENTS LIMITED,
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